Scenarios 7 through 9 for the TBLM Use case

Nokhum Markushevich

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Scenarios 7-9

- *Scenario 7 is mostly about adapting aggregated real and reactive load to current weather conditions.*
- *Scenario 8 is about developing aggregated real and reactive load dependencies on weather conditions and time for the short-term forecast.*
- Scenario 9 is about developing models of overlaps of different load management functions.

Scope for Scenarios 7 & 8

- *The dependencies of the aggregated load on weather conditions include the combination of*
  - *natural load dependencies,*
  - *distributed generation and storage dependencies, demand response dependencies, and*
  - *the associated impacts of the distribution power flow and DMS applications.*
- *The weather conditions include the localized*
  - *temperature,*
  - *humidity,*
  - *wind direction and velocity,*
  - *cloudiness,*
  - *sunlight.*

Load Components of TBLM (1)

- Natural load of different load categories, like
  - Residential of different classes,
  - Commercial of different classes
  - Industrial of different classes
- These loads are changing in the times of day, week, season, and are also differently dependent on the weather conditions.

Load Components of TBLM (2)

- Distributed generation (DG) of different types.
  - The reciprocating and fuel cell DG can be time dependent based on schedules, or technological cycles.
  - The renewable DG is strongly dependent on the weather, including the sunlight cycles and the intermittency of the weather.
- The representation of the DG injections of real power under intermittent weather conditions implies probabilistic models.
  - In addition to statistic values of the aggregated load, such models introduce the degree of uncertainty of the model that can be used in the risk management.
- The injections/absorption of the DG reactive load is dependent on the performance of the real load and on the modes of volt/var control.

Load Components of TBLM (3)

- Electric storage (ES). The charging/discharging times may be predominantly dependent either on the energy price or on ancillary service requirements.
- These dependencies may be complicated by an ES optimization procedure.
- Also, the times and the duration of the charging/discharging of ES are dependent on the previous performance of the ES.
- Some ES can be set to compensate the fluctuations of the injections by other DGs. Then it becomes weather-dependent

Load Components of TBLM (3)

- Load management capabilities, including Demand response (DR) and Remedial Action schemes (RAS).
- The demand response capabilities are different at different times and under different weather conditions.
  - The relationships between the DR capabilities and the weather conditions may be not straightforward ones. For instance, if a hot weather continues for a longer period of time, the DR potential may reduce.
- The RAS capabilities are also different under different weather conditions due to the changes of the amount and composition of natural load, DG and ES.

Load Components of TBLM (4)

- Impacts of the central and local Volt/var/Watt control caused by the changes of the above-mentioned components.
- These impacts include
  - changes of the natural real and reactive load due to the load-to-voltage dependencies,
  - changes of the DG and ES operations due to the central and/or local volt/var controls,
  - changes of the real and reactive power losses caused by the changes of loads, DG, ES and performance of the IVVWO.

Information sources for local weather conditions

- Weather systems
- Bellwether meters
- Selected DER/micro-grid controllers
- Selected Customer EMS
  - ➢ By analyzing the historic patterns of loads with embedded DERs and/or of stand-alone DER/micro-grids under different weather conditions of a particular area, the essential components of the DER models can be categorized for the entire local area.

Example of information on local weather conditions

- PV DER performance recorded under clear sky at a given time is the reference condition
- The data from the bellwether meters collected during this time interval show that the average DER generation is 50% of the reference load with a standard deviation of 5%,
    - it is likely to be a light overcast condition and can be presented as a particular category of DER performance.
- If the standard deviation were 20%,
    - It is likely to be due to fast-moving clouds, and would be presented by another category.

Attributes of TBLM to be adapted to weather conditions

- Load models, including the probabilistic characteristics
- Capability curves
- Load-to- voltage and frequency dependencies
- Demand response
- Other

The procedure

- TBLM developer defines the weather conditions based on the available forecasts and triggers the runs of DOMA under these conditions and for look-ahead timeframes.
- These DOMA reference models are used by IVVWO to finalize the aggregated effect of the ambient conditions at the given times
- TBLM developer summarizes the results of the look-ahead DOMA and IVVWO series into the look-ahead aggregated TBLM attributes
  - Note: with the high penetration of DER, the dependency of the aggregated loads on the weather conditions becomes critically significant for the EMS decision-making applications

The Scope of Scenario 9 (1)

- The load management can be executed through several programs, such as:
  - Volt/var control in distribution
  - Dynamic pricing
  - Demand response/direct load control
  - Interruptible load/Load curtailment
  - Remedial Actions
    - Under-frequency load shedding
    - Under-voltage load shedding
    - Predictive/special load shedding

The Scope of Scenario 9 (2)

- All of these load management means result in changes of both real and reactive load.
- The Volt/var control and the dynamic pricing are, probably, the least influential on the real load due to the limited load elasticity to them.
- The Volt/var control can significantly impact the reactive load.
- The Demand response/direct load control and the Interruptible load/load curtailment may be in the range of single-digit percentage on the average, but can be greater in local areas.
- *The most significant load reduction results from the remedial actions, and the greatest overlaps of the load under these programs can be expected.*

Background Information

- Some of the least-intrusive load management means can be expected to be used as variables under normal operating conditions
- A more critical use of load management means is a part of the steady-state and dynamic analyses of emergency situations.
- With high penetration of DER in distribution and with the real threat of compromising the cyber security, an exponential growth of the variety of possible emergency situations can be expected.
- This requires N-m (instead of N-1) analyses and also increases the probability of cascading development of emergencies.

Example Combinations of Contingencies

	a	b	c	d	e	f	g	h	i	j
a. Loss of transmission lines	-			X			X	X	X	X
b. Loss of generating units		-			X		X	X	X	X
c. Loss of bus section	X		-	X			X	X	X	X
d. Loss of transformers (auto-transformers)				-			X	X	X	X
e. Loss (or lack of dynamic reserve) of reactive power source, e.g., SVC					-			X	X	X
f. Loss of substation (one voltage level plus transformers)	X		X	X	X	-	X	X	X	X
g. Failure of Remedial Action System							-			
h. Loss of significant DER in distribution								-		
i. Failure of software (cyber-security)	X	X	X	X	X	X	X		-	X
j. Loss of critical communications	X	X	X	X	X	X	X			-

- With such a diversity of combinations of contingencies different sequences of load reducing/shedding actions are possible. The overlapping of loads among different load management schemes may impact the development of the contingencies

Example: Common load for a portion (group) of load management means

Load Reduction Means	% of total load connected to the load management means	Percentage of total load included in both load management means						
		Demand response	Load curtailment	Voltage reduction	Block Load Shedding	Predictive LS	UFLS	UVLS
Demand response	5	5	0	0.15	0.384	0.72	0.624	0.48
Load curtailment	4	0	4	0.12	0.32	0.6	0.52	0.4
Voltage reduction	3	0.15	0.12	3	0.24	0.45	0.39	0.3
Block Load Shedding	8	0.384	0.32	0.24	8	1.2	1.04	0.8
Predictive LS	15	0.72	0.6	0.45	1.2	15	4.3	3.3
UFLS	13	0.624	0.52	0.39	1.04	4.3	13	5
UVLS	10	0.48	0.4	0.3	0.8	3.3	5	10

Effective load management capabilities after one load management means is executed

Load Reduction Means	% of total load connected to the load management means	Percentage of total load after the following load reduction is implemented						
		Demand response	Load curtailment	Voltage reduction	Block Load Shedding	Predictive LS	UFLS	UVLS
Demand response	5		5	4.85	4.616	4.28	4.376	4.52
Load curtailment	4	4		3.88	3.68	3.4	3.48	3.6
Voltage reduction*	3	2.85	2.88		2.76	2.55	2.61	2.7
Block Load Shedding	8	7.616	7.68	7.76		6.8	6.96	7.2
Predictive LS	15	14.28	14.4	14.55	13.8		10.67	11.67
UFLS	13	12.376	12.48	12.61	11.96	8.67		8
UVLS	10	9.52	9.6	9.7	9.2	6.67	5	

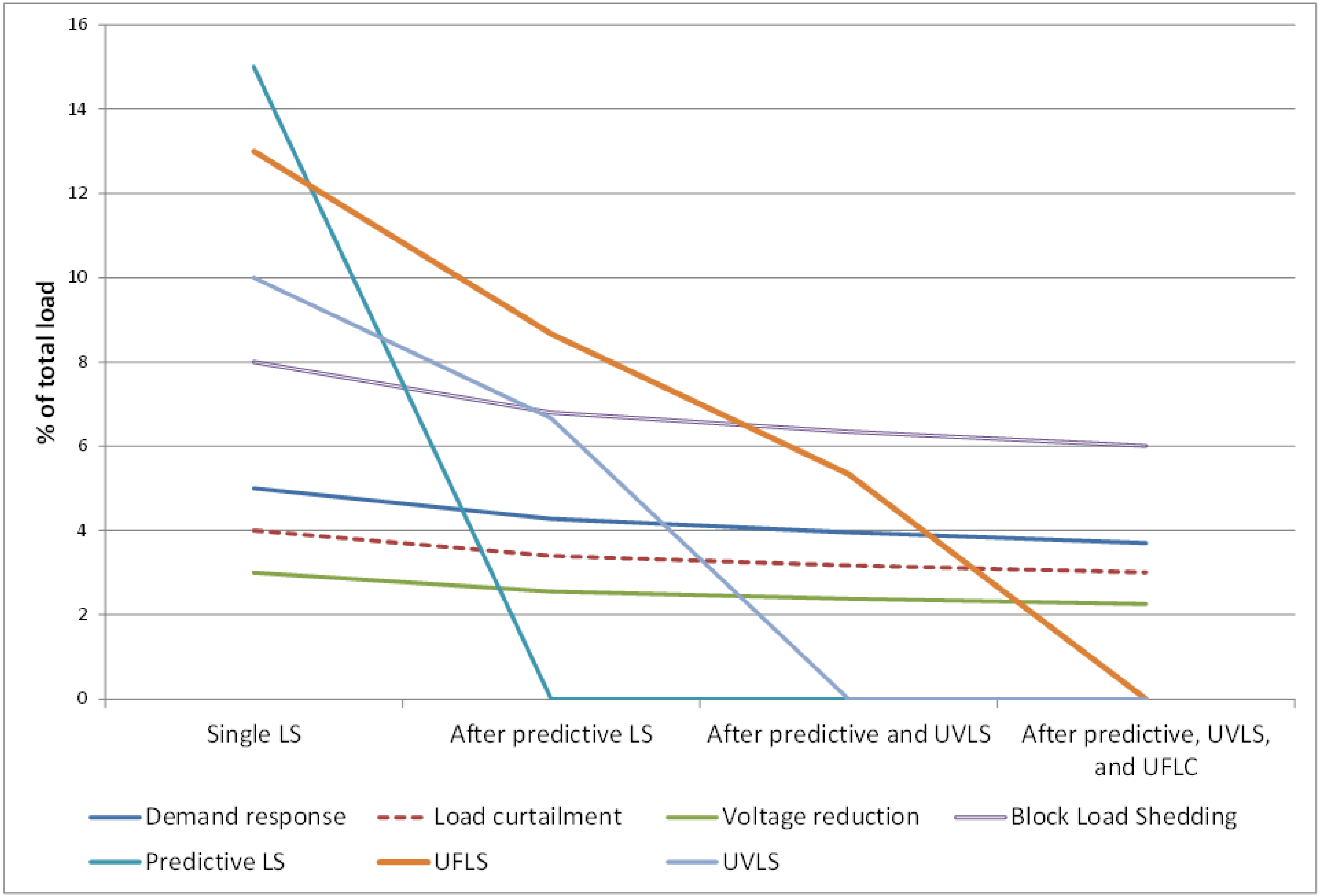
Common load for a portion (group) of load management means after the predictive load shedding option is executed

Load Reduction Means	% of total load connected to the load management means	Percentage of total load included in both load management means						
		Demand response	Load curtailment	Voltage reduction	Block Load Shedding	Predictive LS (implemented)	UFLS	UVLS
Demand response	4.28	4.3	0.0	0.1	0.3		0.4	0.3
Load curtailment	3.4	0.0	3.4	0.1	0.2		0.3	0.2
Voltage reduction	2.55	0.1	0.1	2.6	0.2		0.2	0.2
Block Load Shedding	6.8	0.3	0.2	0.2	6.8		0.6	0.5
Predictive LS								
UFLS	8.67	0.4	0.3	0.2	0.6		8.7	3.3
UVLS	6.67	0.3	0.2	0.2	0.5		3.3	6.7

Effective load management capabilities after the predictive load shedding and UVLS options are implemented and another load management means is executed

Load Reduction Means	% of total load connected to the load management means	Percentage of total load after the following load reduction is implemented						
		Demand response	Load curtailment	Voltage reduction	Block Load Shedding	Predictive LS (implemented)	UFLS	UVLS (Impl.)
Demand response	3.96		3.96	3.86	3.65		3.70	
Load curtailment	3.17	3.17		3.10	2.97		3.00	
Voltage reduction	2.38	2.29	2.30		2.23		2.25	
Block Load Shedding	6.35	6.04	6.15	6.20			6.01	
Predictive LS								
UFLS	5.33	5.08	5.16	5.21	4.99			
UVLS								

Effective load shedding capabilities of different load management means in a sequence of execution



Primary Information

- Data models of RAS (IEC 61850)
- Data models of DR, interruptible/curtainable loads, RAS (IEC 61850, ANSI C12x…- another use of customer-site information for TnD)
- Triggering events:
  - significant change in Demand Response participation (contractual constraints, limited duration, etc.)
  - re-allocation of interruptible /curtailable and block load shedding sites;
  - re-allocation or changes of settings of UFLS, UVLS, Predictive LS, etc.

The procedure (1)

- DOMA develops matrices of all relevant load management means and overlapping loads between them
- Optional: DOMA develops chain scenarios of the execution of the load management alternatives (or the TBLM developer does it).
- IVVWO determines the load management capability of IVVO for the initial state and for the chain scenarios

The procedure (2)
(Why DOMA and IVVWO?).

- DOMA possesses all needed information on load management, circuit topology, and the impact of the load management on the power flow results
- There are two effects of IVVWO on load management:
  - The load reduction by IVVWO is smaller due to eliminations of participating loads shed by other means
  - The load reduction by IVVWO is increased due greater tolerances for voltage reduction because of the lighter loading and smaller voltage drops after loads is shed by other means

The procedure (3)

- The TBLM developer defines the times for the look-ahead studies according to the setup of the look ahead requirements for the TBLM
  - e.g., for three hours ahead divided into 30-minute intervals.
  - the EMS application may run for the worst-case scenario during this time.
  - the forecasted models for the time of the worst-case scenario should be available to the EMS applications
- The TBLM developer initiates the series of DOMA and IVVWO runs according to the defined times.

Thank you!

Questions, Comments?